Recovering Value from Waste

Anaerobic Digester System Basics

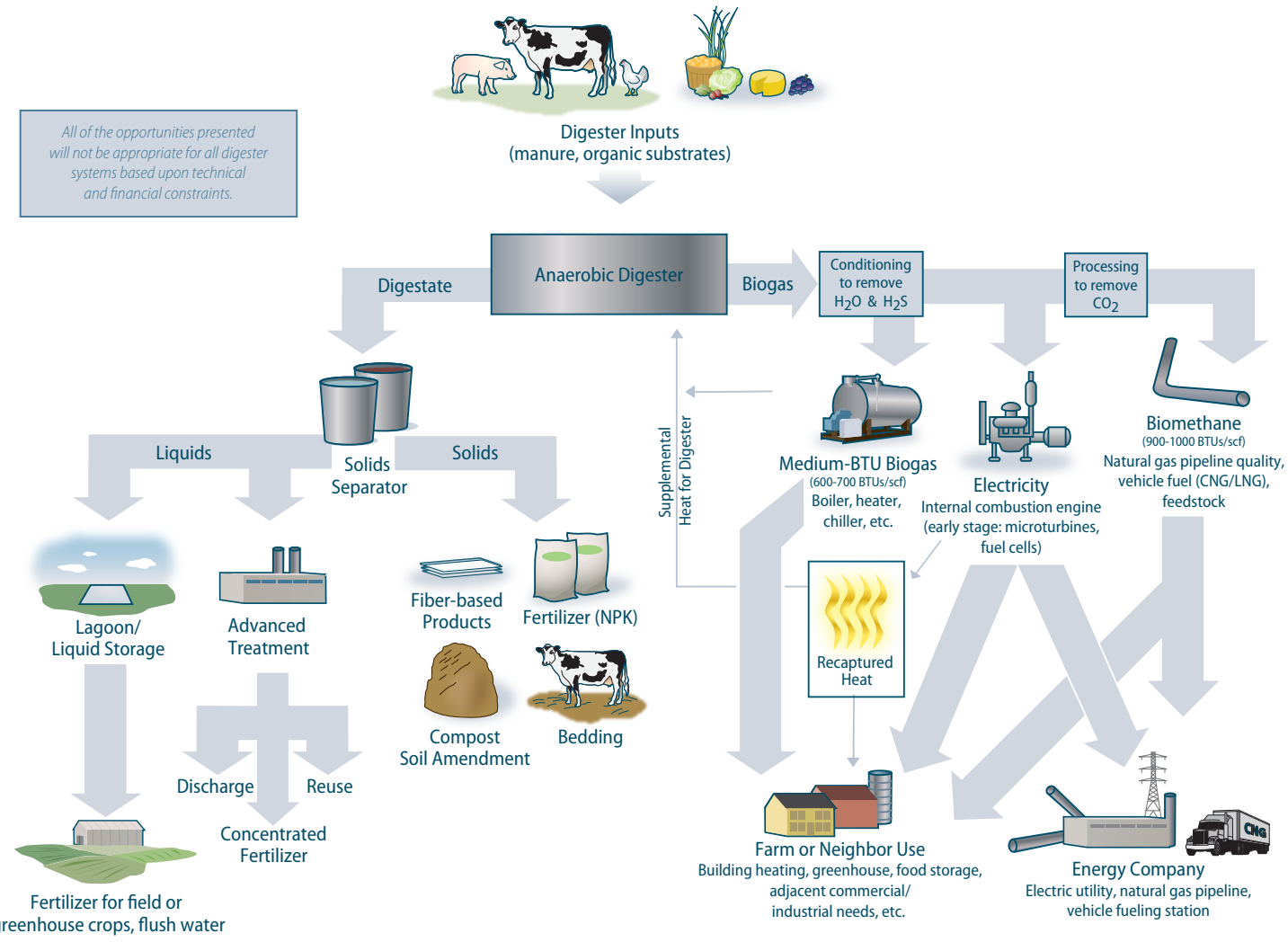
December 2011

Biogas recovery may hold the key to unlocking the financial and environmental benefits of managing manure generated from livestock operations and organic wastes from the agriculture and food production sectors. Biogas is produced when manure and other organics decompose anaerobically (without oxygen) in a digester. Anaerobic digester (AD) systems reduce greenhouse gas emissions (methane), limit odor from manure storage and application, allow for methane capture and use, and effectively separate the solid and liquid portions of the digestate into valuable byproducts (bedding, soil amendment, fertilizer). AD systems differ from standard manure storage in that they are specially designed to optimize the production of biogas and allow for energy production. By using or selling the energy, biogas and byproducts, farms can turn animal waste into an opportunity for cost savings, profits, and environmental stewardship.

Understanding Anaerobic Digestion

AD systems create value from waste by generating and collecting biogas and separating manure into usable, marketable components. The diagram below demonstrates how they create value for farms and their communities.

Basic Anaerobic Digester System Flow Diagram



Assessing Feasibility

Whether an AD system makes sense for a facility depends on the following factors and other site-specific details: type and scale of the livestock operation, how the manure is handled, the frequency of manure collection, and the facility's potential uses for the recovered biogas. Other important factors include the financial goals of the farmer and project partners, access to organic substrates, and the ability to obtain interconnect and/or energy off-take agreements.

- **Type and scale of livestock operation.** The type of operation and the number of animals present influence whether a facility will be able to profitably operate an AD system. Traditionally, flush and scrape dairies with at least 500 dairy cows and swine farms with 2,000 pigs (5,000 pigs if manure is managed in deep pits) were considered technically and economically viable, as were poultry and beef operations that meet the criteria below. However, some AD systems are now designed specifically for smaller operations. Additionally, smaller operations have been successful in making projects feasible by designing their systems to include co-digestion of manure and organic substrates. When done appropriately, co-digestion can increase biogas production and thus energy output. Access to long-term, stable supplies of organic substrates are critical for this option.

- **Manure handling.** Traditional wet AD systems can best accommodate manure handled as a liquid, slurry, or semisolid. The total solids content of the manure helps determine whether anaerobic digestion is a good fit for the facility. Dry AD systems for high-solids waste sources are also emerging in the marketplace and can be feasible depending upon site-specific manure management and farm needs.

- **Frequency of manure collection.** Facilities best suited for AD systems typically have stable year-round manure production and collect at least 50 percent of the manure daily.

- **Gas use.** The biogas generated can be used as fuel for electricity generation in engine-generator sets;[1] directly as a medium-Btu fuel in on-site or adjacent furnaces, chillers, kilns, boilers or other fuel needs; upgraded for use in vehicles or distribution through natural gas pipelines; or flared. The electricity or biogas can be used on farm or sold to local entities or energy utilities. Heat can also be captured from the engine-generator sets, furnaces, or boilers and used to produce hot water or heat for use in the digester (to maintain proper operating temperature), barns, homes, or other on-site structures. When choosing among gas use options, facilities must examine each option's potential effects on financial performance, associated labor requirements, the skills needed to maintain and repair the equipment, or the need for a third-party system operator.

[1] *Fuel use for electricity generation in microturbines and fuel cells are options, but there is limited operating experience with manure digester biogas.*

Selecting an AD System

Once a facility determines that an AD system would support its operational and business goals, it must select the most appropriate system for its needs. Typical operating characteristics of different digester types are summarized below; however, operational conditions vary widely depending on regional and site-specific considerations.

Plug Flow Digester – Long, narrow tank, typically heated and below ground, with impermeable gas-collecting cover. Contents move through the digester as new manure is added. Modified plug-flow systems can use vertical mixing techniques. These systems work best with dairy manure, handled by scraping, with minimal bedding.

- **Percent solids:** 11 to 13%
- **Hydraulic retention time (HRT):** 15+ days
- **Co-digestion:** not optimal
- **Number of operational U.S. systems including manure:** approximately 80

Complete Mix Digester – Above- or below-ground heated or unheated tank with impermeable gas-collecting cover. Contents mixed by motor or pump. Complete mix digesters work best when there is some dilution of the excreted manure with water (e.g., milking center wastewater); manure should be handled via slurry.

- **Percent solids:** 3 to 10%
- **HRT:** 15+ days
- **Co-digestion:** yes
- **Number of operational U.S. systems including manure:** approximately 50

Covered Lagoon – In-ground earthen or lined lagoon with impermeable gas-collecting cover. Contents can be heated or mixed but are not typically due to volume. Covered lagoons work best with manure handled via flush or pit recharge collection systems in warmer climates.

- **Percent solids:** 0.5 to 3%
- **HRT:** 40 to 60 days
- **Co-digestion:** not optimal
- **Number of operational U.S. systems including manure:** approximately 30

Up-flow Anaerobic Sludge Blanket (UASB)/ Induced Blanket Reactor (IBR) – High-rate, above-ground, heated vertical tanks where the influent is added continuously to the bottom of the reactor. Bacteria are suspended in the reactor due to the flow of the influent. These systems are best suited for consistent, homogenous waste streams.

- **Percent solids:** less than 3% for UASB, and 6 to 12% for IBR
- **HRT:** typically 5 days or less
- **Co-digestion:** yes
- **Number of operational U.S. systems including manure:** approximately 5

Fixed Film/Attached Media Digester/ Anaerobic Filters – Above-ground, heated tank containing media such as plastic or wood chips on which bacteria attach and grow. Manure waste is passed through the media and is digested as it comes into contact with the bacteria attached to the media. These digesters work best with manure in temperate and warm climates.

- **Percent solids:** 1 to 5%
- **HRT:** Typically 5 days or less
- **Co-digestion:** yes
- **Number of operational U.S. systems including manure:** less than 5

Anaerobic Sequencing Batch Reactors (ASBR) – Typically an above-ground, heated tank with an impermeable roof that collects gas. Manure is added and removed from the reactor in batches. There are four phases in the ASBR cycle: fill, react, settle, and decant. An ASBR is best suited for treating dilute wastes (i.e., manure handled via slurry).

- **Percent solids:** 2.5 to 8%
- **HRT:** Typically 5 days or less
- **Co-digestion:** yes
- **Number of operational U.S. systems including manure:** less than 5

High-Solids Fermentation – Heated above-ground, airtight container. Designed for high solids manure and other organic substrates (e.g., silages such as corn, grass, or rye; food waste; ethanol and biodiesel production byproducts such as distillers grains or glycerin).

- **Percent solids:** 18%+
- **HRT:** 2 to 3 days
- **Co-digestion:** yes
- **Number of operational U.S. systems including manure:** less than 5

To learn more about the operational digester systems referenced in the previous descriptions (locations, animal populations feeding digester, biogas use, system developer and more), visit AgSTAR's National Digester Database at www.epa.gov/agstar/projects/index.html

Find Out More

AgSTAR offers a variety of tools, resources, and events to increase the use of AD systems. More information on AD system funding, development, and operation is available on the AgSTAR website at www.epa.gov/agstar.

EPA United States Environmental Protection Agency

Office of Air and Radiation,
Mail Code 6207J
www.epa.gov
EPA-xxx-x-xx-xxx

Photos Courtesy of:

Pagels Ponderosa; Crave Brothers Farm; Utah State University, Conley Hansen; Environmental Credit Corporation; Energy Center of Wisconsin; University of Florida, Ann Wilkie; Cornell University; Oregon Department of Agriculture; AgSTAR